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RESEARCH ARTICLE

Game-based practice versus traditional practice in computer-based writing strategy training: effects on motivation and achievement

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Abstract Achieving sustained student engagement with practice in computer-based writing strategy training can be a challenge. One potential solution is to foster engagement by embedding practice in educational games; yet there is currently little research comparing the effectiveness of game-based practice versus more traditional forms of practice. In this study, the ARCS model (Keller, Perform Instr 26(8):1–7, 1987b) was used to investigate the motivational characteristics of different practice conditions. To this end, 175 students were randomly assigned to one of four experimental conditions: game-based, question-based, model-based, and writing-based practice. All students first learned strategies to write an essay introduction. Subsequently, students practiced using the strategies in the four different conditions. Game-based practice was expected to positively affect ARCS-related motivation toward practice. Results showed that students perceived game-based practice as significantly more interesting and engaging than question-based practice. However, although game-based practice was perceived more positively, only model-based and question-based practice demonstrated a beneficial impact on students' ability to implement the writing strategies. These results underline the necessity of interconnecting motivational and instructional design when developing practice methods for computer-based writing strategy training.

Keywords Serious games · Game-based learning · Writing strategy instruction · ARCS model

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Introduction

Writing is essential to success, yet many students lack writing expertise and fail to master basic writing skills during their formative education years. One means of developing writing skills is through instruction in writing strategies (e.g., De La Paz and Graham 2002; Graham 2006; Graham and Perin 2007; Kellogg and Whiteford 2009). Writing strategy instruction explicitly and systematically teaches students to use strategies for planning, drafting, and revising (e.g., Graham and Perin 2007), which entails explaining and modeling each strategy and providing students with ample opportunities for sustained practice (Roscoe et al. 2013). Research has demonstrated that such instruction is beneficial to students, particularly less skilled writers (e.g., Graham 2006).

Few studies have contrasted the relative merits of different *forms* of practice in writing strategy instruction (Zimmerman and Kitsantas 2002), and research has specifically neglected how these forms of practice engage (or fail to engage) students *motivationally*. In this case, we use the term motivation to refer to individuals' intrinsic and extrinsic goals to achieve or avoid a given outcome, which in turn influences their choices and expenditure of effort (e.g., Keller 1999). Across different modes of practice, motivation may play a crucial role in students' willingness to practice and perhaps place an upper bound on the effectiveness of writing strategy instruction (Kellogg and Whiteford 2009, p. 254). As such, a deeper understanding of students' motivation related to the instructional design of practice opportunities (Keller 1987b) may help us elicit greater student investment in strategy practice (Huang et al. 2006).

In this study, we consider design in motivating practice opportunities within computer-based writing strategy training. Specifically, we contrast the benefits of game-based and more conventional forms of practice on students' perceived motivation (as defined by the ARCS motivational design model; Keller 1987b) and students' learning and application of writing strategies.

Applying the ARCS motivational design model to writing strategy practice

The ARCS model posits four conceptual components (i.e. Attention, Relevance, Confidence, and Satisfaction) that must be fulfilled for people to become and remain motivated (Keller 1987b). *Attention* refers to learners' responses to the provided instructional materials and serves as a prerequisite for learning. Attention-building principles arouse and sustain curiosity and interest in the instructional content. After obtaining learners' interest, perceived *Relevance* of instruction plays an important role (e.g., Hidi et al. 2002). Relevance-building principles link instructional materials to students' prior learning experiences, learning objectives, and the future use of acquired skills. Motivation is further influenced by learners' beliefs or *Confidence* that success is possible or probable (e.g., Cheng and Yeh 2009; Pajares 2003). Confidence-building principles foster expectations of success and encourage students to perceive success as under their control. Finally, practice, feedback, and positive attitudes towards the learning content promote *Satisfaction,* which positively affects students' further motivation (e.g., Keller 1999). Empirical findings show a positive relationship between motivational processing (Attention, Relevance, and Confidence) and Satisfaction (e.g., Huang et al. 2010). Moreover, research suggests that incorporating ARCS design principles enhances the motivational impact of instructional materials and activities (e.g., Cheng and Yeh 2009; Huang et al. 2006; Jakobsdóttir and Hooper 1995; Keller 1999).

Conventional forms of writing strategy practice task students with studying and imitating model texts and/or applying novel strategies in their own writing (e.g., Graham and Perin 2007). Both common forms of strategy practice can enhance students' writing skills compared to general instructions for simply working productively, making the paper better, and writing a paragraph (e.g., Graham et al. 1995; Zimmerman and Kitsantas 1999), freewriting without explicit instruction, or questions guiding the writing (e.g., Knudson 1989). These conventional forms of practice can also align with ARCS principles. *Studying and imitating model texts* is a form of practice that engages student reflection, which is related to Keller's (1987b) attention-building principle of inquiry arousal. Model texts also demonstrate what students can and should strive for in their own writing (e.g., Knudson 1989). Thus, when reading model texts, students are provided with authentic and useful examples that emphasize the relevance of the practice. In contrast, *strategy application practice* can engage relevance-building principles such as using goal-oriented tasks and matching students' motives (Keller 1987b) because it allows students to learn by doing (e.g., Schunk and Swartz 1993; Zimmerman and Kitsantas 1999). To successfully apply the strategy, the student must mobilize and sustain effort which, particularly when combined with feedback, can also improve students' self-efficacy (confidence) for writing (e.g., Schunk and Swartz 1993).

As an alternative to more conventional approaches, practice tasks can also be embedded within games or game-like environments. Game-based practice is increasingly recognized as a means to support not only skill acquisition, but also knowledge acquisition and strategy automaticity (e.g., Van Eck 2006). Games are interactive, goal-directed problem-solving activities guided by rules (e.g., Wouters et al. 2013). As students play and strive to overcome game challenges, they must gradually practice and master the knowledge, strategies, and skills required to win. In addition, games also provide feedback that allows players to monitor their progress (e.g., Dempsey et al. 2002; Wouters et al. 2013), and this feedback can serve an important prompt for self-regulated learning and growth (Butler and Winne 1995; Narciss 2008; Shute 2008).

In *educational games*, the objective is to leverage core game features and game interactions in ways that support more formal learning (e.g., Roscoe et al. 2013). Several taxonomies describe potentially engaging game features, such as fantasy, narrative, sensory stimuli, rules, goals, challenge, assessment, competition, and control (e.g., Bedwell et al. 2012; Garris et al. 2002; Wilson et al. 2009). Games often incorporate elements of fantasy or narrative that contextualize the interaction and provide a sense of purpose to the tasks. Narratives generally consist of characters, protagonists, plots, conflict, and resolution. Combining these elements can increase uncertainty and build suspense, and also increase a sense of immersion, presence, and flow (Barab et al. 2010). Likewise, games with various sensory stimuli, such as moving targets, can help to sustain attention (Dempsey et al. 2002). A specific set of rules helps learners focus on what to do in order to attain the goal of the game (e.g., Dempsey et al. 2002). Thus, rules support learners' active participation in the game. Furthermore, the goal structure of the game is made transparent and clear to the learner which may foster performance (e.g., Garris et al. 2002; Latham and Locke 2007). Challenge, assessment, competition, and control may help students to judge their learning progress (e.g., Garris et al. 2002). Together, such game features are assumed to enhance students' enjoyment and engagement in playing the game which in turn may increase students interest in continuing to practice the strategies (e.g., Roscoe et al. 2013).

Within educational gaming, mini-games represent one common approach in which simple games focus on a concrete skill or topic (Panagiotakopoulos 2011; Smith and Sanchez 2010). Mini-games often employ a *question–answer approach* similar to testing

during strategy training (Ricci et al. 1996). Such an approach is similar to taking a test on learning material, which has been shown to improve retention compared to spending an equivalent amount of time restudying the material (e.g., Roediger and Karpicke 2006). Benefits from testing are generally attributed to the retrieval processes in which students engage during testing, such as elaboration or creating multiple retrieval routes. Interactive, computer-based questions have the additional potential of providing immediate feedback to the student (Proske et al. 2012). Interactive question answering requires ongoing interaction between the student and the computer in which students solve the presented question. This fulfills Keller's (1987b) attention-building principle of stimulating an attitude of inquiry. Furthermore, giving students feedback and opportunities for repetition and correction potentially scaffolds them toward independently correcting incorrect solutions (McDaniel and Wooldridge 2012). In this way, confidence-building principles are implemented.

From an instructional point of view, educational mini-games employing a question–answer approach offer a number of promising motivational attributes for practicing and applying writing strategies. For example, students might build confidence for the strategies by practicing them in the games before incorporating these strategies in their own essays (Roscoe et al. 2013). Combinations of graphics, sound, and narrative could be used to enhance the sensory experience, fulfilling Keller's attention-building principle for arousing curiosity and interest (e.g., Gunter et al. 2008; Rieber 1996). Mini-games also have clear goals, simple rules, and are relatively easy to play (e.g., Panagiotakopoulos 2011; Paras and Bizzocchi 2005), which allows students to repeatedly focus on applying writing strategies with a goal of learning and improving (Kellogg and Whiteford 2009). This focus aligns with Keller's principle of building relevance via goal orientation and motive matching. As with any game, mini-games can provide timely information to players about their performance (i.e. feedback, Roscoe et al. 2013). In this way, students' confidence and satisfaction can be fostered (e.g., Paras and Bizzocchi 2005). In sum, practicing by means of mini-games can fulfill a majority of the motivational design principles described by Keller (1987b). In practical terms, mini-games are also relatively easy and cheap to develop and integrate within computer-based training compared to complex games with lengthy narratives, intricate game mechanics, and high-end graphics.

Empirical studies have examined collections of mini-games focused on specific tasks or skills, including strategy games that target problem-solving and decision-making (e.g., Ke 2008) and adventure games focused on reading and math skills (e.g., Rosas et al. 2003). Students have typically played these games over several weeks for at least 1 h per week. During this time, control groups either remained in their teacher-led classrooms (Rosas et al. 2003) or completed paper-and-pencil drills similar to the mini-games (Ke 2008). Such research has consistently reported positive effects on motivation but also a lack of performance and achievement differences between conventional practice and game-based practice (e.g., Ke 2008; Rosas et al. 2003).

Few researchers have investigated the effectiveness of mini-games under shorter practice durations (<2 h), but such studies also suggest that mini-games may increase students' motivation to practice (e.g., Jackson et al. 2011; Klein and Freitag 1991). Mixed results have been reported for achievement. Mini-games have been found to be equivalent to worksheets including the same practice questions (Klein and Freitag 1991) or associated with lower achievement compared to guided practice with feedback (e.g., Jackson et al. 2011). In the latter study, however, only the traditional practice group was allowed to improve their initial answer after receiving feedback. Students in the game-based condition received feedback on the quality of their answer but were not allowed to revise. Thus,

differences in the instructional design may account for decrements in performance with game-based practice.

The present study

One purpose of this study is to further investigate the extent to which students perceive game-based practice as more motivating, according to the ARCS motivational design model, compared to more traditional methods of practice in computer-based writing strategy training. ARCS-related motivation is a situational state that affects the level of concentration and attention toward an assigned learning task (Rodgers and Withrow-Thorton 2005). Notably, we do not, in this study, investigate motivational gains by comparing pretest and posttest motivation to learn.

Table 1 compares the presence of the ARCS design principles in game-based practice to two conventional forms of practice (model-based practice and writing-based practice). To equate the materials used within the mini-game, Table 1 also compares game-based practice to a similar question–answer condition without game attributes. We hypothesize that mini-games for writing strategy practice will positively influence students' reported attention, confidence, and satisfaction compared to conventional forms of writing strategy practice (i.e. studying and imitating model texts and applying novel strategies in one's own writing). We further expect game-based practice to grab more attention of students than a similar non-game question–answer condition. No differences were expected between the different practice conditions in terms of perceived relevance.

A second goal is to examine the effects of practice method on strategy knowledge and application of writing strategies. Several studies have observed a lack of difference between traditional practice and game-based practice for performance and achievement (e.g., Ke 2008; Klein and Freitag 1991). Thus, we expect that game-based practice may be as effective as conventional forms of practice in terms of learning achievement. However, game-based practice may not exceed other forms of practice in terms of achievement. Finally, we explore whether students' perceived motivation differentially affects posttest achievement.

Method

Participants

Participants ($N = 175$) were volunteer German university students enrolled in English courses to acquire and improve English fluency. The topic of the courses was English at level B2+ and C1 of the Common European Framework of Reference for Languages (Common European Framework of Reference for Languages: Learning, Teaching, Assessment (CEFR)). At level B2+ and C1 of the CEFR, a student is expected to use a wide range of language structures with few errors and express ideas and opinions on a variety of topics. They can exchange information reliably and have an active command of the essentials of the language. Students were assigned to the courses at the beginning of the semester via an electronic placement test. Instructional materials and practice were offered in English as a part of this curriculum. Participants were 28 % female with a mean age of 22.54 years ($SD = 2.27$). Reported majors were primarily technical (37 % engineering, 26 % computer science, 17 % economics, 14 % environmental science, and 6 % other).

Table 1 Alignment of different forms of practice with ARCS design principles

ARCS strategies	Game-based	Question-based	Model-based	Writing-based
Attention principles				
Create curiosity, wonderment by using novel approaches, injecting personal and/or emotional material	+	−	−	−
Increase curiosity by asking questions, creating paradoxes, generating inquiry, and nurturing thinking challenges	+	+	+	−
Sustain interest with variations in presentation style, concrete analogies, human interest examples, and unexpected events	+	+	−	−
Relevance principles				
Provide statements or examples of the utility of the instruction, and either present goals or have learners define them	+	+	+	+
Make instruction responsive to learner motives and values by providing personal achievement opportunities, cooperative activities, leadership responsibilities, and positive role models	+	+	+	−
Make the materials and concepts familiar by providing concrete examples and analogies related to the learners' work	−	−	+	+
Confidence principles				
Establish trust and positive expectations by explaining the requirements for success and the evaluative criteria	+	+	−	−
Increase belief in competence by providing many, varied, and challenging experiences which increase learning success	+	+	−	−
Use techniques that offer personal control, and provide feedback that attributes success to personal effort	+	+	−	−
Satisfaction principles				
Provide problems, simulations, or work samples that allow students to see how they can now solve "real-world" problems	+	+	−	−
Use verbal praise, real or symbolic rewards, and incentives, or let students present the results of their efforts ("show and tell") to reward success	+	+	–	–
Make performance requirements consistent with stated expectations, and provide consistent measurement standards for all learner's tasks and accomplishments	+	+	−	−

Their mean duration of enrollment was 5.51 semesters ($SD = 2.80$). Participants received a text on academic writing guidelines in compensation.

Design and procedure

A randomized, controlled experiment was conducted consisting of four phases: *pretest*, *learning*, *practice*, and *posttest*. Participants were randomly assigned to one of four practice conditions with a between-subjects design: *game-based*, *question-based*, *model-based*, and *writing-based* practice. There were no significant differences between the groups for gender, age, course of studies, semester, and English language skills. All materials were provided in English.

After a pretest assessing prior strategy knowledge, all students studied strategies for writing an essay introduction by watching four short videos. These videos were obtained from the Introduction Building lesson of the computer-based writing strategy training system Writing Pal (W-Pal, McNamara et al. 2012; Roscoe and McNamara 2013; Roscoe et al. in press). W-Pal was developed to provide writing strategy instruction, practice, and feedback to high school students and entering college students. W-Pal synthesizes key principles of strategy instruction, modularity, extended practice, and formative feedback (Dai et al. 2011; Roscoe and McNamara 2013). The interdisciplinary development of the system spans over 5 years with input from cognitive psychology, linguistics, computer science, and English education. Several studies have demonstrated the effectiveness of W-Pal and guided iterative development and improvements to the system (e.g., modifications of the user interface or mode of instruction, see for example Roscoe et al. 2013; Roscoe and McNamara 2013; Roscoe et al. in press).

After viewing the instructional videos, students were offered different practice possibilities depending upon their assigned condition. *Game-based practice* ($n = 41$) consisted of playing Essay Launcher, a mini-game in which students applied some of the introduction building strategies to rescue stranded spaceships. *Question-based practice* ($n = 46$) was identical but all game elements (i.e., the narrative, graphics, and points) were removed. Game-elements were identified based on current game taxonomies (e.g., Bedwell et al. 2012; Garris et al. 2002; Wilson et al. 2009). *Model-based practice* ($n = 47$) prompted students to analyze examples of good introductions. The *writing-based practice* condition ($n = 41$) served as a control condition. Students in this condition were asked to practice the previously taught introduction building strategies by writing introductions on given prompts. All students were required to complete three rounds of practice.

After practicing, students completed a posttest that elicited students' motivational perceptions of the practice activity (IMMS, Keller 2010), and assessed both posttest strategy knowledge and application of introduction building strategies. The experimental session lasted about 90 min.

Materials

Learning materials

The Introduction Building lesson consisted of four 5-min, strategy-focused videos (Roscoe et al. in press). The lesson began with an Overview video that presented the rationale for the lesson and previewed the strategies to be covered. Subsequently, three specific videos provided students with instruction on how to write introductions using the *TAG* mnemonic: Thesis Statements, Argument Preview, and Attention-Grabbing Techniques. Students

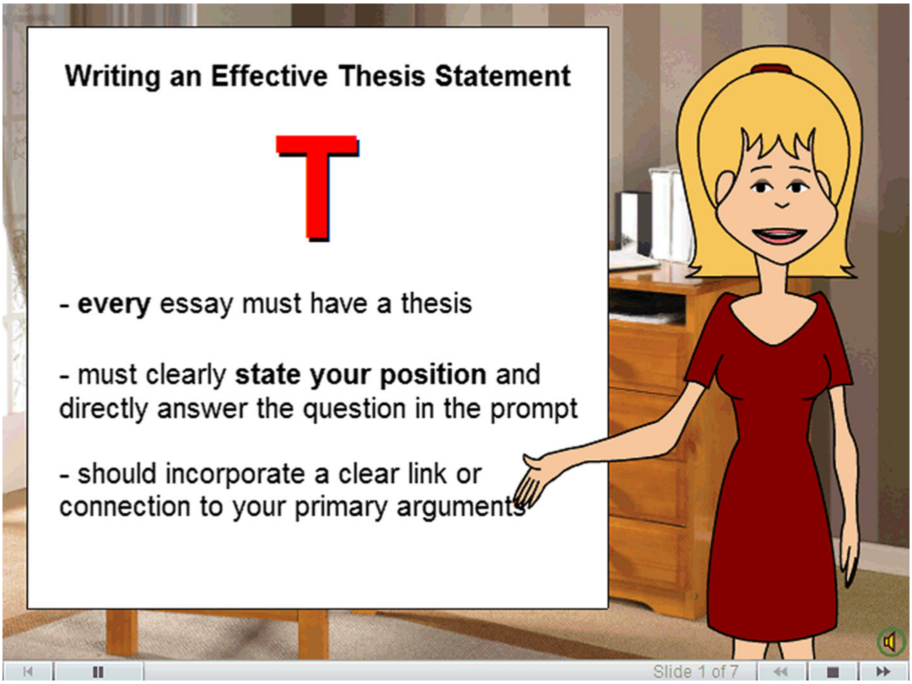

Fig. 1 Screenshot of a video

learned how to author each of these elements, and were provided with five techniques to make the introduction interesting (e.g., using a personal anecdote). Each video was presented by an animated character and illustrations and examples appeared on a whiteboard (see Fig. 1). Completing the videos unlocked associated practice tasks, depending upon condition. In all practice conditions, information about the features of thesis statements and attention-grabbing techniques were available by clicking on a Help button.

Conditions

Game-based practice The mini-game was an identification practice task in which students examined given text excerpts to label key strategies covered in the lesson, or to identify how strategies may be used to improve the text (Roscoe and McNamara 2013). In this mini-game, the core game characteristics of fantasy, narrative, rules, goals, sensory stimuli, challenge, assessment, competition, and control were incorporated. Students applied several lesson strategies to rescue five stranded spaceships (fantasy, narrative), including choosing an appropriate thesis statement for the given paragraph and identifying the attention-grabbing technique exhibited in the paragraph (rules, goals, see Fig. 2). Incorrect answers triggered a failed launch animation with sound effects (sensory stimuli) and feedback on why the answer was incorrect. Correct answers rewarded the students with an animation showing the ship returning to Earth (sensory stimuli). Students had a total of ten attempts to save the five spaceships (challenge, control). At the end of the game, students earned points depending on the number of rescued spaceships (i.e. the number of correctly labeled paragraphs) and the number of remaining attempts (competition). Thus,

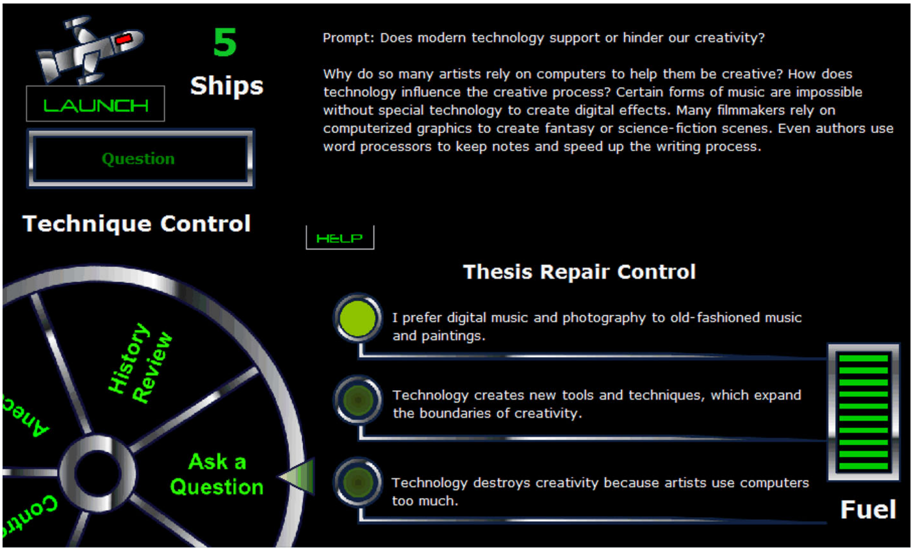

Fig. 2 Screenshot of game-based practice

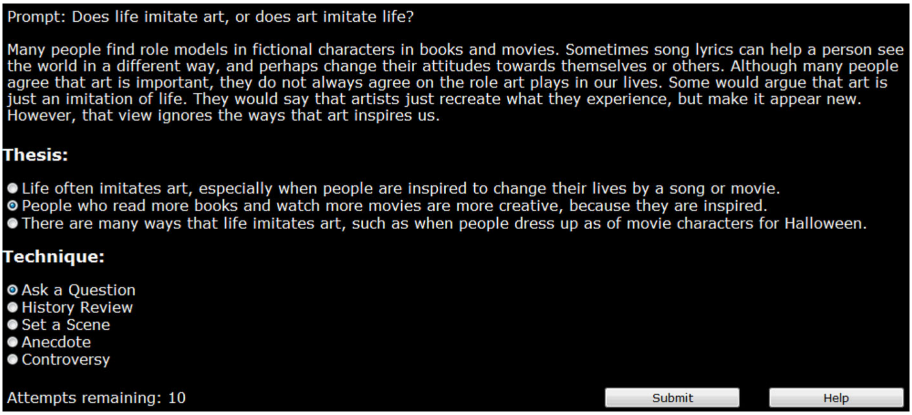

Fig. 3 Screenshot of question-based practice

students could judge the quality of their strategy application based on their game score (Roscoe and McNamara 2013).

Question-based practice To equate practice materials across conditions, question-based practice was identical to the mini-game but all game elements were removed. As in the game, students were required to select appropriate thesis statements and identify attention-grabbing techniques (see Fig. 3). When students made errors, corrective feedback was delivered. In each round, students were allotted ten attempts to label five given paragraphs.

Model-based practice Model-based practice consisted of studying five complete examples of introduction paragraphs. These examples demonstrated all elements of introduction

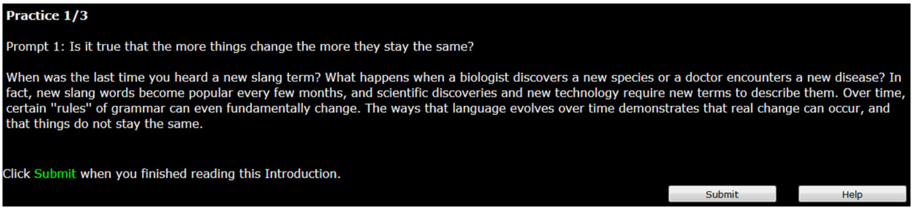

Fig. 4 Screenshot of model-based practice

building strategies: effective theses, argument previews, and attention-grabbing techniques. Students were prompted to analyze these examples to learn how to reproduce the critical introduction elements later (see Fig. 4).

Writing-based practice Students in the writing-based practice condition were prompted to use their knowledge of introduction building strategies to write introductions on three different prompts. In the instructions, students were told to practice formulating good thesis statements and different attention-grabbing techniques.

Measures

Instructional materials motivation survey (IMMS)

The *Instructional Materials Motivational Survey* (IMMS, e.g., Keller 2010) was used to assess ARCS-related motivation. The IMMS is a 36-item measure that evaluates how a practice activity relates to each of the four components of the ARCS model (Rodgers and Withrow-Thorton 2005): Attention (12 items, Cronbach's alpha = 0.82), Relevance (9 items, Cronbach's alpha = 0.75), Confidence (9 items, Cronbach's alpha = 0.78), and Satisfaction (6 items, Cronbach's alpha = 0.83). Survey items were adapted to the study by changing the word "this lesson" to "the practice activity" (e.g., "There was something interesting at the beginning of *this lesson* that got my attention." was changed to "There was something interesting at the beginning of *the practice activity* that got my attention."). Each item was rated on a five-point scale from "1" (not true) to "5" (very true).

Strategy knowledge test

Strategy knowledge was assessed twice, once before learning (pretest strategy knowledge) and again after practice (posttest strategy knowledge). The strategy knowledge test comprised eight multiple-choice questions assessing students' ability to (a) define and describe introduction building strategies, (b) recognize and apply introduction building strategy examples, and (c) understand the importance of introductions. Four questions had a single correct answer, and four questions had more than one correct answer option. Students received credit for choosing any correct answer. Strategy knowledge test scores are reported as a percentage of a maximum possible score of 19 points.

Application of strategies test

The strategies application test was administered after the posttest strategy knowledge test and consisted of ten multiple choice-questions in which students read example

introductions. Students completed the test by either (a) identifying missing thesis statements or attention-grabbing techniques, (b) labeling the thesis and attention-grabbing technique, or (c) improving the provided introduction. Application test scores are reported as a percentage of a maximum possible score of 20 points.

Time on task

The time students spent watching the videos and practicing was calculated from log-files recorded by the system.

Statistical analyses

The first analysis examined whether students perceived game-based practice as more motivating, according to the ARCS model, than more conventional methods of computer-based writing strategy practice. Preliminary analyses revealed significant differences between the four practice conditions for both video-viewing and practice time (see Table 2). Post-hoc comparisons using the Tukey HSD test indicated that students in the question-based practice condition invested significantly less time watching the videos than did students in the writing-based practice condition ($p = 0.021$). Furthermore, practice time in model-based practice was significantly shorter than in the other three conditions ($p < 0.01$ for comparison with all conditions). Consequently, Pearson's correlation coefficients were computed between the IMMS scales, prior strategy knowledge, video-viewing time, and practice time to determine whether these variables needed to be included as covariates. The IMMS subscales did not significantly correlate with any of these variables. Thus, we conducted a MANOVA including the IMMS subscales as dependent variables and experimental condition as the between-subjects factor (game-based, question-based, model-based, writing-based practice).

The second analysis addressed the effects of different practice conditions on achievement. Posttest achievement was measured using a strategy knowledge test and an application test. Separate analyses of covariance (ANCOVA) were conducted to assess the between-subjects effect of practice condition on the two posttest measures. Following (Rausch et al. 2003), prior strategy knowledge was used as a covariate for both analyses. There were also significant, positive relationships between video-viewing time and posttest strategy knowledge ($r = 0.18$, $p < 0.05$). Thus, video-viewing time was entered as a further covariate for the strategy knowledge posttest. Preliminary analyses evaluating the homogeneity-of-regression slopes assumption indicated that the relationship between the covariates and the dependent variables did not differ significantly as a function of the independent variable.

The third analysis explored whether students' ARCS-related motivation differentially affected posttest achievement. Two separate hierarchical regression analyses with interactions were performed. The criterion variables were the two posttest measures, i.e. the strategy knowledge and application of strategies tests. Students' (a) prior strategy knowledge, (b) perceived attention, relevance, confidence and satisfaction of practice, as well as (c) three dummy-coded variables representing information about the condition (with writing-based practice serving as the reference group) were entered at step 1 (Model 1). The interaction between each dummy-coded variable and each IMMS scale was added at step 2 (Model 2).[1] All predictor variables were centered. Following Aiken and West (1991), we conducted simple slope tests to probe significant interactions.

[1] Similar regression analyses were conducted additionally including video-viewing time and practice time as predictors. The pattern of results did not change when they were included.

Table 2 Means, standard deviations and statistical comparisons of measured variables

	Game-based ($n = 41$) *M (SD)*	Question-based ($n = 46$) *M (SD)*	Model-based ($n = 47$) *M (SD)*	Writing-based ($n = 41$) *M (SD)*	Statistical comparison				
					df	*F*	*MSE*	Partial η^2	*p*
Prior strategy knowledge (%)	50.8 (14.0)	45.6 (15.8)	47.8 (16.3)	49.0 (12.6)	(3, 171)	0.9	220.0	0.02	0.42
Time on task									
Video time (min)	16.2 (1.3)	15.5 (1.6)	15.8 (1.3)	16.4 (1.8)	(3, 171)	3.2	8,029.1	0.05	0.02*
Practice time (min)	20.9 (3.3)	19.8 (3.6)	11.5 (3.9)	22.0 (7.8)	(3, 171)	43.1	87,456.0	0.43	<0.01**
Motivation									
Attention[a]	3.2 (0.6)	2.9 (0.7)	3.0 (0.7)	3.1 (0.6)	(3, 171)	2.8	0.4	0.05	0.05*
Relevance[a]	3.2 (0.6)	3.2 (0.6)	3.3 (0.6)	3.3 (0.6)	(3, 171)	0.3	0.4	0.01	0.81
Confidence[a]	3.7 (0.7)	3.8 (0.6)	3.5 (0.6)	3.5 (0.6)	(3, 171)	2.7	0.4	0.05	0.05*
Satisfaction[a]	3.0 (0.9)	2.9 (0.7)	2.6 (0.8)	2.7 (0.8)	(3, 171)	2.2	0.6	0.04	0.10
Performance									
Post strategy knowledge (%)	67.1 (16.7)	66.4 (16.6)	66.0 (17.5)	67.2 (15.4)	(3, 169)	0.2	241.4	0.00	0.90
Post application of strategies (%)	68.1 (17.3)	69.2 (16.2)	71.6 (15.0)	61.4 (16.8)	(3, 170)	3.8	245.1	0.06	0.01*

* $p < 0.05$; ** $p < 0.01$

[a] Scale averages are reported

Results

Prior strategy knowledge

Table 2 presents the means and standard deviations for students' prior strategy knowledge. A one-way ANOVA showed no significant differences between the four groups with respect to prior strategy knowledge.

ARCS-related motivation

Table 2 and Fig. 5 show the descriptive statistics for the IMMS scales assessing students' ARCS-related motivation as a function of condition. A MANOVA revealed a significant main effect of condition (Wilk's $\Lambda = 0.73$, $F(4,168) = 4.74$, $p < 0.01$, partial $\eta^2 = 0.10$). This result indicates that the effect for group differences in the MANOVA accounted for 10 % of the group-differences. This exceeds the cutoff for a medium effect size using the guidelines proposed by D'Amico et al. (2001) in which values of 0.01, 0.06, and 0.14 indicate small, medium, and large effect sizes when measured by partial eta squared (see also Richardson 2011). Univariate follow-up analyses indicated that main effects were significant for the Attention and Confidence subscales and marginally significant for the Satisfaction subscale (see Table 2). The Satisfaction subscale accounted for 4 % of the group-differences, whereas both the Attention and Confidence subscales accounted for a somewhat larger proportion of 5 %. This exceeds the criterion for a small effect size (D'Amico et al. 2001; Richardson 2011). This effect size is consistent with the literature that also found small effects of a game on motivational measures (e.g., Bai et al. 2012). Post-hoc comparisons using the Tukey HSD test indicated that the mean score for the Attention subscale was significantly higher for the game-based practice condition than for question-based practice ($p = 0.047$). Furthermore, perceived confidence in the question-based practice group was marginally higher than in the model-based practice group ($p = 0.072$).

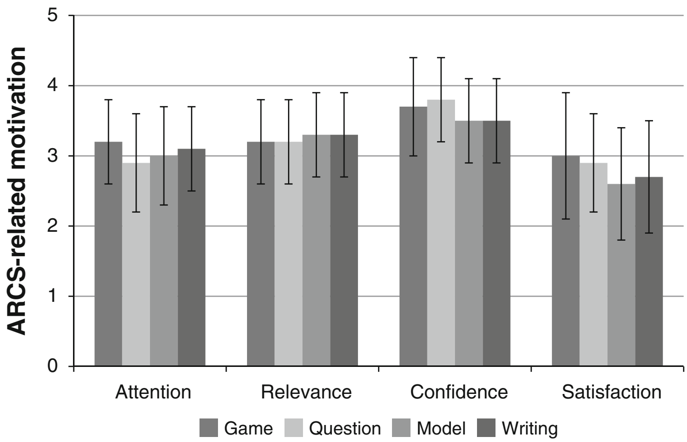

Fig. 5 Mean motivational attitudes towards practice method. *Error bars* represent standard deviations

Posttest strategy knowledge and application of strategies

Table 2 presents the means, standard deviations, and indicators of statistical comparisons for the posttest measures of strategy knowledge and application of strategies (see also Fig. 6). As shown on the left side of Fig. 6, the ANCOVA on posttest *strategy knowledge* did not reveal a significant effect of condition. However, as displayed on the right side of Fig. 6, the ANCOVA on posttest performance in terms of *application of strategies* showed a significant effect of condition which accounted for 6 % of the between subjects variance. This exceeds the criterion for a medium effect size (D'Amico et al. 2001; Richardson 2011). Follow-up tests were conducted to evaluate pairwise differences among the adjusted means for practice condition. The Bonferroni procedure was used to control for Type I error across the pairwise comparisons. The results showed that students in the model-based practice condition performed significantly better, controlling for the effect of their prior strategy knowledge, than did students in the writing-based practice condition ($p = 0.011$). In addition, practice by answering questions marginally outperformed practice by writing ($p = 0.056$). There were no statistically significant differences between game-based and conventional forms of practice.

Role of perceived ARCS-related motivation for posttest achievement

Two separate, two-step hierarchical regression models were tested to investigate whether students' perceived motivation differentially affected posttest performance in the four conditions. Results of these analyses are presented in Table 3. For the posttest on *strategy knowledge*, Model 1 (including the main effects of prior knowledge, ARCS-related motivation, and condition) accounted for 14 % of the variation in posttest strategy knowledge. The results show that only prior strategy knowledge significantly predicted posttest achievement. Introducing the interaction between each dummy-coded variable and each IMMS scale (Model 2) explained an additional 10 % of variation in posttest strategy knowledge, but this change in R^2 was not significant ($F(12,154) = 1.78$, $p = 0.06$).

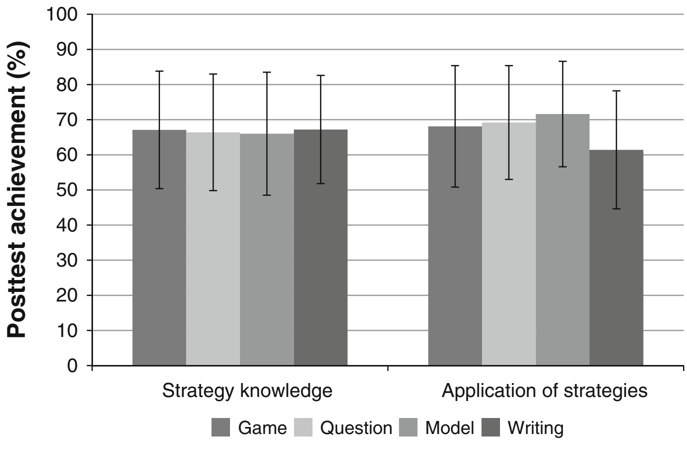

Fig. 6 Achievement on the posttest measures of strategy knowledge and application of strategies. *Error bars* represent standard deviations

Table 3 Summary of hierarchical regression analysis for variables predicting posttest achievement

Variable	Strategy knowledge						Application of strategies					
	Step1			Step 2			Step 1			Step 2		
	B	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Prior strategy knowledge	0.33	0.0.8	0.30**	0.28	0.25**	0.09	0.27	0.08	0.24**	0.17	0.09	0.15*
Motivation												
Attention	−4.26	2.90	−0.17	1.12	0.04	6.49	0.58	2.91	0.02	3.90	6.30	0.15
Relevance	3.73	3.26	0.13	1.93	0.07	6.20	3.72	3.26	0.13	10.04	6.02	0.36
Confidence	2.26	2.51	0.09	−3.16	−0.12	4.49	2.28	2.51	0.09	−3.01	4.36	−0.11
Satisfaction	1.46	2.59	0.7	1.91	0.09	4.96	−2.94	2.59	−0.14	−12.22	4.82	−0.56*
Condition												
Writing versus model (W vs. M)	−1.38	3.39	−0.04	−1.05	−0.03	3.67	10.17	3.39	0.27**	8.90	3.56	0.24*
Writing versus question (W vs. Q)	−1.61	3.64	−0.04	0.17	0.00	3.75	8.89	3.65	0.24*	7.44	3.64	0.20*
Writing versus game (W vs. G)	−0.93	3.57	0.2	−2.68	−0.07	3.80	6.66	3.57	0.17	2.92	3.69	0.07
Condition × motivation												
W versus M × attention				−6.58	−0.14	8.69				−1.64	8.44	−0.03
W versus Q × attention				−7.49	−0.16	7.85				−8.90	7.63	−0.19
W versus G × attention				−3.62	−0.07	10.28				15.92	9.99	0.30
W versus M × relevance				7.40	0.14	8.57				5.85	8.33	0.11
W versus Q × relevance				14.08	0.26	9.32				−11.26	9.06	−0.20
W versus G × relevance				−16.37	−0.31	9.12				−26.04	8.86	−0.48**
W versus M × confidence				14.44	0.29*	7.02				2.84	6.82	0.06
W versus Q × confidence				2.64	0.05	6.67				11.32	6.48	0.22
W versus G × confidence				8.27	0.16	7.29				1.95	7.08	0.04
W versus M × satisfaction				−8.49	−0.20	7.31				0.16	7.10	0.00
W versus Q × satisfaction				−6.15	−0.13	7.39				15.30	7.17	0.31*

Table 3 continued

Variable	Strategy knowledge						Application of strategies					
	Step1			Step 2			Step 1			Step 2		
	B	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
W versus G × satisfaction				6.74	0.17	7.13				15.99	6.92	0.40*
R^2		0.14**			0.24**			0.15**			0.30**	

* $p < 0.05$; ** $p < 0.01$

Condition was represented as three dummy-coded variables with writing-based practice serving as the reference group

For posttest performance of *application of strategies*, Model 1 explained 15 % of the variation in posttest application of strategies. Adding the interaction terms as predictors explained an additional 15 % of the variation in posttest application of strategies and this change in R^2 was significant ($F(12,154) = 2.67$, $p < 0.01$). Three interactions were significant: Writing versus Game × Relevance, Writing versus Question × Satisfaction, and Writing versus Game × Satisfaction (see Table 3), suggesting that the effect of perceived ARCS-related motivation on posttest application of strategies depended on the condition.

Simple slopes for these associations were tested for low (−1 *SD* below the mean) and high (+1 *SD* above the mean) scores on the respective IMMS scale. The effect of practice condition on students' posttest strategy application performance depended on *perceived relevance of practice*. Students in the writing-based practice condition who perceived the practice activity as less relevant performed poorly in comparison to those who perceived high relevance of the writing-based practice ($t(171) = 2.34$, $p < 0.05$) and in comparison to those in the game-based practice condition ($t(171) = 3.16$, $p < 0.01$). By contrast, there was no effect of perceived relevance in the game-based condition. Figure 7 plots the simple slopes for this interaction.

The effect of practice condition on students' posttest strategy application performance further depended on *perceived satisfaction of practice*. Those in the writing-based practice condition who experienced more satisfaction performed poorly in comparison to those who reported more satisfaction with game-based practice ($t(171) = 2.23$, $p < 0.05$) and in comparison to those in the question-based practice ($t(171) = 3.03$, $p < 0.01$). Furthermore, those in the writing-based practice condition who reported more satisfaction performed poorly in comparison to those who experienced less satisfaction to the writing-based practice in the writing-based practice condition (game-based practice: $t(171) = 2.64$, $p < 0.01$, question-based practice: $t(171) = 2.58$, $p < 0.05$). By contrast, there was no effect of perceived satisfaction in the game-based and question-based conditions. Figs. 8 and 9 plot the simple slopes for these interactions.

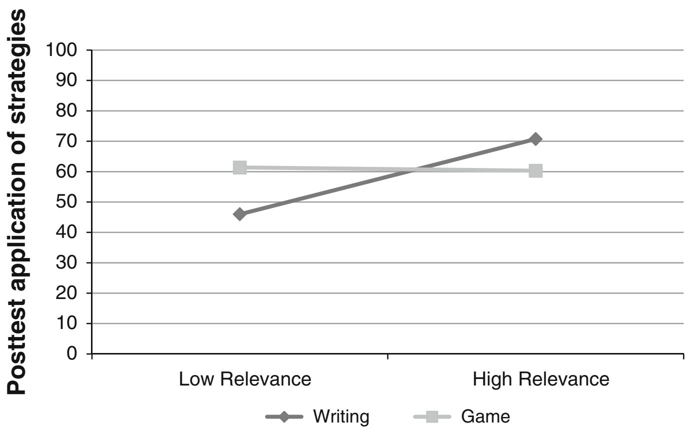

Fig. 7 Simple slopes for writing-based and game-based practice conditions predicting application of strategies at low and high relevance of practice

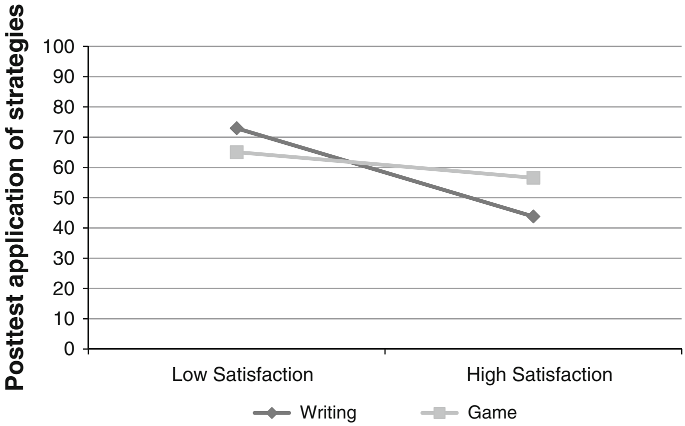

Fig. 8 Simple slopes for writing-based and game-based practice conditions predicting application of strategies posttest at low and high satisfaction of practice

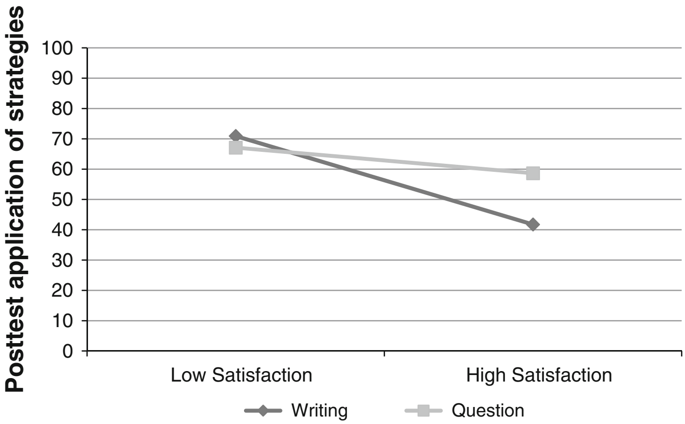

Fig. 9 Simple slopes for writing-based and question-based practice conditions predicting application of strategies posttest at low and high satisfaction of practice

Discussion

Learning writing strategies requires a significant motivation to practice (Kellogg and Whiteford 2009). The aim of this study was to investigate (a) the degree to which game-based practice in writing strategy training was perceived as more motivating according to the ARCS model (Keller 1987a) than conventional methods of practice, (b) the degree to which game-based practice positively influenced students' knowledge and application of writing strategies, and (c) the degree to which students' perceptions of practice differentially affected posttest achievement in the different practice methods. Game-based practice was compared to a similar question-based practice condition without game elements, as well as two traditional forms of practice (i.e., model-based and writing-based practice).

Effects of game-based practice on motivation

Students perceived game-based practice as significantly more interesting and engaging than question-based practice. These two tasks were isomorphic; the practice tasks were identical except for the game or non-game context. Thus, game-based practice appears to have the potential to grab students' attention. This is important because gaining and sustaining learners' attention to the instructional content is considered crucial for learning (Keller 1987b).

Although descriptive data point in the expected direction, students perceived game-based practice as equally motivating (according to the ARCS model) compared to model-based or writing-based practice. Practice by analyzing model texts or trying to apply an acquired writing strategy is common in university classrooms. For example, writing style guides and textbooks frequently provide deconstructed examples along with worksheet style practice opportunities (e.g., Hacker and Sommers 2011). Thus, students may have perceived these practice methods as being relevant to their prior learning experiences, current learning objectives, or future use of the new writing skills. Furthermore, both the modeling and writing practice conditions asked students to focus on the concurrent application of the new introduction building strategies either in analyzing the given models or in trying to use the strategies. In contrast, game-based practice provided a concentrated, short experience for only some of the new introduction building strategies. Thus, students in the model-based and writing-based practice conditions, more so than students of the game-based practice condition, may have experienced their practice conditions as a means to improve their personal writing (Schunk and Swartz 1993). For this reason, they may have judged their practice to be more attention-holding, confidence-building, and satisfying than expected. In addition, participants of the game-based practice group were required to play the game and playing time was pre-defined. In leisure time, game-players typically decide themselves which game to play and how long to play it. It is possible that the lack of control on these decisions negatively affected students' ARCS-related motivation towards the mini-game (e.g., Jakobsdóttir and Hooper 1995; Wouters et al. 2013).

Although students who engaged in model-based practice performed better on posttest measures of strategy application, their *expectations* of success were lower than for those in question-based practice. Students' confidence in model-based practice might have been diminished because studying high-quality models may have lead them to feel that achieving similar results would be beyond them (Zimmerman and Risemberg 1997). Confidence can be enhanced by providing feedback on the success of strategy application (Schunk and Swartz 1993). Thus, the results of this study suggest that feedback on students' progress, as realized in the question-based and game-based practice conditions, is of particular importance when designing motivating practice tasks in computer-based writing strategy training (Cameron and Dwyer 2005; Ricci et al. 1996; Rieber 1996).

Effects of game-based practice on achievement

As expected, and in line with prior research, game-based practice was just as effective as conventional practice forms in terms of achievement (e.g., Ke 2008; Klein and Freitag 1991). Although practice by answering questions slightly outperformed practice by writing, game-based practice did not. Question-based practice was nearly identical to game-based practice in terms of the cognitive processes required during practice. Thus, game features may have affected practice effectiveness. For example, students often begin new games with a trial-and-error strategy before reading instructions, which could decrease

meaningful utilization of practice time (Dempsey et al. 2002). This interpretation is supported by prior research in which short-term use of mini-games also was associated with lower achievement (Jackson et al. 2011). Other research has shown that students learning with a text aligned to ARCS design principles showed significantly lower knowledge acquisition in an immediate posttest (Astleitner and Lintner 2004). However, these negative effects of game-based practice or alignment with ARCS design principles disappeared when a long-term perspective over several weeks was considered (e.g., Astleitner and Lintner 2004; Jackson et al. 2011).

The results here indicated that students in the model-based practice condition significantly outperformed writing-based practice in terms of strategy application at posttest. This advantage of model-based practice is in line with research showing that encouraging students' reflection fosters learning (e.g., Garris et al. 2002; Knudson 1989; Moreno and Mayer 2005; Wouters et al. 2013). Furthermore, the results of this study indicate that asking students to apply a new strategy without specific instructional support or feedback may not be a very effective practice method in writing strategy training (Leemkuil and de Jong 2011). This approach may be more suitable in later stages of skill acquisition when students have gained more control over their strategy application via sufficient practice of the individual techniques (Kellogg and Whiteford 2009; Zimmerman and Kitsantas 1999).

Differential effects of ARCS-related motivation on achievement

Hierarchical regression analyses revealed that the relationship between perceived relevance and posttest strategy application, as well as satisfaction and posttest strategy application, was different in the game-based and writing-based practice conditions. Whereas both motivational components did not influence strategy application in game-based practice, they seemed to differentially affect strategy application in writing-based practice. These results suggest that game-based practice may particularly improve achievement for students who perceive conventional practice methods as irrelevant (Means et al. 1997).

Unexpectedly, students reporting satisfaction with writing-based practice performed more poorly than students reporting low satisfaction with writing-based practice. This result requires additional research to provide a coherent explanation. Post hoc, one might speculate that those who invested less effort into the writing process were more satisfied because the task was less challenging—in turn, a consequence may have been lower performance. By contrast, those who invested greater effort into the writing task may have been more frustrated (e.g., by lack of feedback), but they also may have learned more. Unfortunately, these potential relations cannot be fully tested within the current study.

Limitations

One potential concern regards the stability of the IMMS. For example, several studies that have investigated the validity of the IMMS by confirmatory factor analysis found varying results with respect to the IMMS structure and item number (e.g., Huang et al. 2006; Loorbach et al. 2014). Notably, however, the IMMS is designed to measure situation-specific attitudes rather than more stable psychological traits (Keller 2010). Thus, varying outcomes when using this measure may be explicable by the situation-specificity of the IMMS (e.g., Huang et al. 2006). Along these lines, the objective in this study was to not to measure students' generalized level of motivation toward one practice activity in

computer-based writing strategy training compared to another. Rather, our goal was to compare students' self-reported reactions across different situations (i.e. different practice activities) guided by an established motivational design model. To this end, the IMMS' sensitivity to situation-specific motivation was considered to be one of its strengths. For example, we found that students in all conditions reported a moderate to high levels on the Attention, Relevance, and Confidence sub-scales of the IMMS. However, they did not perceive high levels of satisfaction from practicing. These results indicate that there is room for motivational improvement in all forms of practice (e.g., Huang 2011). As such, the IMMS items can identify potentially critical motivational components of particular interest to instructional designers when designing practice forms in computer-based writing strategy (e.g., Huang et al. 2006).

A second potential concern regards the generalizability of our results to other games. The Essay Launcher was the sole mini-game used within this study. This game was selected for methodological reasons from a collection of mini-games accompanying the introduction building lesson of W-Pal (McNamara et al. 2012; Roscoe et al. in press). This mini-game focuses on the learning objectives of identifying an adequate thesis statement and distinguishing different attention-grabbing techniques. The application strategies test also requires students to identify that a thesis statement is missing or to improve introductions. These skills were not explicitly practiced by the game-based and question-based practice groups. Transfer of acquired knowledge is considered as a function of the similarity in cognitive processes engaged by the game and the application test (e.g., Tobias et al. 2011). Thus, future research may need to compare traditional methods of practice to a collection of multiple mini-games that more comprehensively cover all learning objectives of the strategy lessons (e.g., Ke 2008; Rosas et al. 2003).

Third, practice time in this study was limited due to methodological reasons. However, given the assumption that motivating practice influences effort rather than performance (Huang 2011; Keller 1987b), it may be that the length of practice was too short to have a measurable effect (e.g., Wouters et al. 2013). Furthermore, it is possible that observed outcomes would not be sustained once the novelty of game-based practice wears off. This suggests that investigating the effectiveness of mini-games for practice should be conducted in a more longitudinal manner, for example by giving the opportunity to practice several times over several weeks (e.g., Jackson et al. 2011; Ke 2008). In addition, investigating motivational pretest–posttest gains from practicing would allow deeper insight into the complex interplay between motivation and achievement in computer-based writing strategy training (e.g., Wouters et al. 2013).

A fourth concern regards the design of the conditions in this study. Our aim in this study was to compare traditional practice forms to game-based practice. Maintaining the ecological validity of writing-based and model-based practice necessarily led to differences in the instructional design of the conditions. To control for this, question-based practice was developed nearly identical to game-based practice. However, to better separate motivational effects of game-based practice, future studies should use more strictly equivalent versions of conditions (e.g., Klein and Freitag 1991). This would allow more closely probing specific circumstances for effectively fostering practice motivation by means of ARCS design principles. In addition, the effects of different forms of practice may be guided by ARCS design principles in different ways. For example, the features that best support student attention and confidence in practice games may not be the same features that achieve these outcomes in more conventional practice. One goal for future research may be to identify features with the greatest impact within or across different practice

forms. For this, it is recommended to adapt the IMMS to the objectives of the particular evaluation (e.g., Huang et al. 2006).

A final consideration is that the effects observed in this study might vary when investigating students working in their native language, or for native English speakers. This possibility certainly merits further study.

Conclusion

The results of this study underscore the necessity of interconnecting motivational and instructional design when developing practice methods for computer-based writing strategy training (e.g., Wouters et al. 2013). Game-based practice might increase the likelihood of student involvement with computer-based writing strategy training (i.e. devote extra time to practice), but it does not guarantee for better achievement. A sound instructional design which, for example, encourages students' reflection on the application of the novel strategies and includes formative feedback, must also be apparent (Ricci et al. 1996). When designed in this manner, mini-games may be a valuable instructional tool and a promising method for facilitating students' acquisition of writing strategies. It is also worth noting that the financial cost to develop multiple mini-games can be relatively low, making game-based practice both educational and cost-efficient.

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